Makoto NISHIDA* & Harufumi NISHIDA**: *Rikuzenoxylon callixyloides* gen. et sp. nov., a silicified wood from the Lower Carboniferous of Iwate Prefecture***

西田 誠*・西田治文**: 岩手県より産出した下部石炭紀の材化石の新属新種 *Rikuzenoxylon callixyloides* について

(Plate I–II)

Although many petrified plants have been described by earlier workers from the Mesozoic of Japan, Paleozoic petrified plants have never been reported. In autumn of 1984, a piece of silicified wood collected from the Lower Carboniferous strata distributed in Ohfunato City was sent to us for identification from the City Museum of Ohfunato City, Iwate Prefecture.

Most of the specimen is badly preserved and only a small part showed preservation that would allow us to describe it anatomically. The specimen resembled araucarian secondary wood and was thought to be the wood of some taxon of the Cordaitopsida, due to its Lower Carboniferous age. The structure of the secondary xylem, tracheids and rays exhibit conspicuous features that have never been reported for both of the Coniferopsida and Cordaitopsida. Therefore, we establish a new form genus for the specimen.

Material and Methods Specimen (No. 849001) is a fragment of silicified secondary xylem, 5.8 cm×2.8 cm in diameter and 1.5 cm long. Only central part, 15 mm×7 mm, has cellular preservation. Cross field pitting, however, was not observed clearly. The specimen was collected by Teru Asano from the Lower Carboniferous Hikoroichi Formation that is exposed at Onimaru, Hikoroichi-machi, Ohfunato City. Micropreparations were made by peel method using 20–25% hydrofluoric acid as an etching reagent.

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Rikuzenoxylon callixyloides Nishida et H. Nishida, gen. et sp. nov. (Figs. 1-3, Pls. I, II)

Description. Wood consisting of tracheids and rays. Wood parenchyma not discernible. Resin canals absent. Growth rings not visible. In cross section, tracheids variable in shape, isodiametric to radially or tangentially elongated rectangular or polygonal, 24-56 μm in radial and 27-59 μm in tangential diameters. Bordered pits of araucarian type on radial walls of tracheids arranged contiguously and alternately in 2-3 rows, occasionally in one and rarely in four rows. Pits are hexagonal with rounded corners and somewhat compressed horizontally, 10-15 μm in diameter, with pit apertures 7-10 μm in diameter. Bordered pits on tangential walls similar to those of radial walls in shape and size, arranged contiguously in one or two rows. If in two rows, pits are alternate. Rays parenchymatous, uniseriate, sometimes biseriate, 1-24, usually 2-20 cells high, measuring 34-980 μm in height, and 10-32 μm in width. Rays separated by 3-10 rows of tracheids. Ray cells in tangential section variable in size and shape; vertically elongate, elliptical or rectangular. In radial section cells of uniseriate rays and uniseriate margin of biseriate rays are isodiametric or nearly so, measuring 36-75 μm high and 50-90 μm in radial length. Median cells of biseriate rays radially elongated, 27-44 μm high and 73-105 μm long. Pits restricted to radial walls. Horizontal and tangential walls smooth. One large half-bordered pit, up to 40 μm in diameter, or occasionally several smaller half-bordered pits, less than 10 μm in diameter, occur in the cross field. Exact number of pits in the cross field is not counted because of ill-preservation.

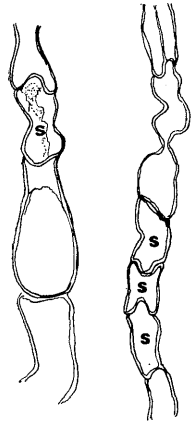

Fig. 1. *Rikuzenoxylon callixyloides*, sp. nov. Cross section of ray showing short cells (s).

Holotype (No. 849001) is in the Laboratory of the first author.

Affinity. The Iwate specimen exhibits several araucarian characteristics. Its important diagnostic chatacters are: 1) bordered pits on radial walls of tracheids arranged in 1-4, usually 2-3, rows, 2) tangential walls exhibiting 1-2 rows of bordered pits that are similar in size and arrangement to those on radial walls; 3) rays uniseriate, sometimes biseriate

and consisting of both radially elongated cells and very short, sometimes square-shaped cells; 4) ray cells conspicuously high, 36–75 μm in height when compared with those of the post-Paleozoic conifers, in which rays are usually 20–30 μm in height; and 5) each cross field having one large or several small bordered pits. Of these 3) and 4) are the most important features. Records of the Paleozoic gymnospermous woods are numerous. Most of them have been included in the form genus *Araucarioxylon*. Lepekhina (1972) reviewed *Araucarioxylon* of the Palezoic and described many species from the Northern Hemisphere. Of these *Araucarioxylon anulatum* Frenzen from the Lower Permian of East Germany and *A. hoegii* V. Lepek. from the Lower Permian of Norway resemble the Iwate specimen in having uni- or biseriate rays which are up to 20–30 cells high. However, *A. anulatum* and *A. hoegii* lack large single pits in the cross field that often appear in the Iwate specimen. *Araucarioxylon steidtmannii* Miner. and *A. ohioense* Dawson from the Lower Carboniferous of North America are similar to our specimen in having bordered pits arranged in 1–4 rows on radial walls of tracheids and rays up to 30 cells high. *Araucarioxylon steidtmannii* and *A. ohioense*, however, have only one to two or three pits in the cross field and differ from our specimen that sometimes has more than several pits. *Araucarioxylon ningahense* Maheshwari from the Upper Permian of India which has uni- or biseriate rays and one to several cross field pits also resembles our specimen. Our specimen differs from *A. ningahense* in ray height. Lower rays, 1–11 cells high, occur in *A. ningahense* while rays of 1–24 cells high occur in our specimen. All species mentioned above lack bordered pits on tangential walls, which are present in the Iwate specimen. Among the species discussed by Lepekhina (1972), *Araucarioxylon kharkhariense* Maithy from the Lower Permian of India and *A. roxoi* Maniero from the Lower Permian of Brasil closely resemble our specimen in having tangential as well as radial pittings, uni- or biseriate rays

Fig. 2. *Rikuzenoxylon callixyloides*, sp. nov. Tangential section of a ray. Arabic numerals show the height of ray cells.

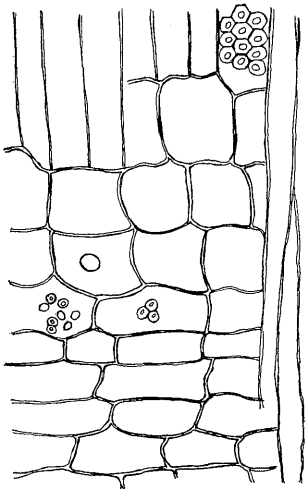

Fig. 3. *Rikuzenoxylon callixyloides*, sp. nov. Radial section showing long and short ray cells.

that measure from 22 to 29 cells high and 2–6 pits in the cross field. The specimen described here is distinct from *A. kharkhariense* and *A. roxoi* that lack a single large pit in the cross field.

Our specimen differs from *Araucarioxylon* in that ray cells are often very short and square in shape in radial view similar to the square cells in rays of dicotyledonous woods. Uniseriate rays and uniseriate marginal cells of biseriate rays are composed of taller cells, while median part of biseriate rays usually consists of lower cells. These cell types resemble square cells and procumbent cells in dicotyledonous woods respectively. This unique ray structure has never been reported in any coniferous or cordaitean woods to our knowledge. Only *Callixylon newberry* (Dowson) Elkins et Wieland from the Upper Devonian of New York has such short ray cells (Arnold 1930). However, *Callixylon* has ray tracheids that are absent in our specimen. *Callixylon* has a so-called *Desmoxylon* type wood (Lepekhina 1972) and is distinct from our specimen that is the araucarian type.

The presence of rays with two distinct cell sizes is an important diagnostic character in Palaeozoic wood. We, therefore, establish a new form genus for this wood type. Generic name originates in the old name, Rikuzen, of the type locality and specific epithet in *Callixylon* that shows similar type of ray structure.

Diagnosis of the genus *Rikuzenoxylon*

Secondary wood exhibiting araucarian type structure. Tangential and radial walls of tracheids pitted by contiguously and alternately arranged bordered pits. Rays parenchymatous, uni- sometimes biseriate, consisting of radially long cells and short cells that look like square in shape in radial section. Ray cells 27 to 70 μm, rarely up to 80 μm in height. Short ray cells 50–80 μm in radial width.

Discussion Paleozoic woods of araucarian type are usually unidentifiable at the genus level by secondary xylem structure since it is usually fundamentally

uniform. Hence their generic diagnoses have to depend on the combination of pith structure, presence of sclerenchyma or thick-walled cells and their distribution patterns in pith, and development of primary xylem, endarch or mesarch (Kräusel, Maithy & Maheshwari 1962, Lepekhina & Yatseko-Khmelevsky 1966, Lepekhina 1972, Prasad 1982). In Recent conifers, presence of sclerenchyma cells in pith is not always valid as a generic diagnostic character, but appears to be a specific feature. Though it would be valid as a generic character in advanced families such as Taxodiaceae and Cupressaceae, it would be invalid in primitive family such as Pinaceae, for example *Picea* (personal communication from Dr. M. Suzuki, Kanazawa University). Hence Mesozoic genus *Piceoxylon* has included both type of species with or without sclerenchyma in pith. Despite this, workers have had to use the presence of sclerenchyma or thick-walled cells in pith as a diagnostic character at the generic level to classify numerous Paleozoic araucarian type woods into adequate groups. While ray cells like square cells in rays of dicotyledonous woods are conspicuous character of our specimen. Similar cells have been recognized only in *Callixylon newberry* (Dawson) Elkins et Wieland (re-examined by Arnold, 1930) from the Upper Devonian of U. S. A. so far we know. Occurrence of the taller ray cells as in our specimen, up to 75–80 μm in height, are usually resrticted to the Paleozoic woods. Coniferous woods in the Mesozoic to Recent usually have lower ray cells, usually 20–30 μm in height. Nishida (1984), however, examined taller ray cells, 40–57 μm in height, in the Tertiary wood, *Araucarioxylon quiriquineanum* Nishida from Chile. Maybe such slightly higher ray cells are not so rare after all. Ray cells that exhibit square in shape in radial view have never been found in the secondary xylem of any species, extant as well as extinct, belonging to Coniferopsida. This is a distinct character in the secondary xylem of araucarian type. Hence we believe that such a conspicuous feature should be applied as a generic diagnostic character.

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Explanation of plates I-II

Plate. I. *Rikuzenoxylon callixyloides*, sp. nov. A: Cross section, ×37. B: Cross section showing short ray cell (arrow), 60 μm long, ×96. C: Cross section showing short ray cell (arrow), 50 μm long, ×187. D: Tangential section showing biseriate ray in the center, ×96. E: Magnified tangential section showing biseriate ray. Arrow: Very high ray cell constituting uniseriate margin. ×187.

Plate. II. *Rikuzenoxylon callixyloides*, sp. nov. A: Radial section, ×90. B: Radial section showing bi- and triseriate bordered pits on radial walls of tracheids, ×187. C: Radial section showing short ray cells like square cells in upper part and long ray cells in lower part, ×187. D: Magnified radial section of C, showing short ray cells, ×420. The cell e is 75 μm in height and 70 μm in width, f is 65 μm in height and 70 μm in width, and g is 65 μm in height and 60 μm in width.

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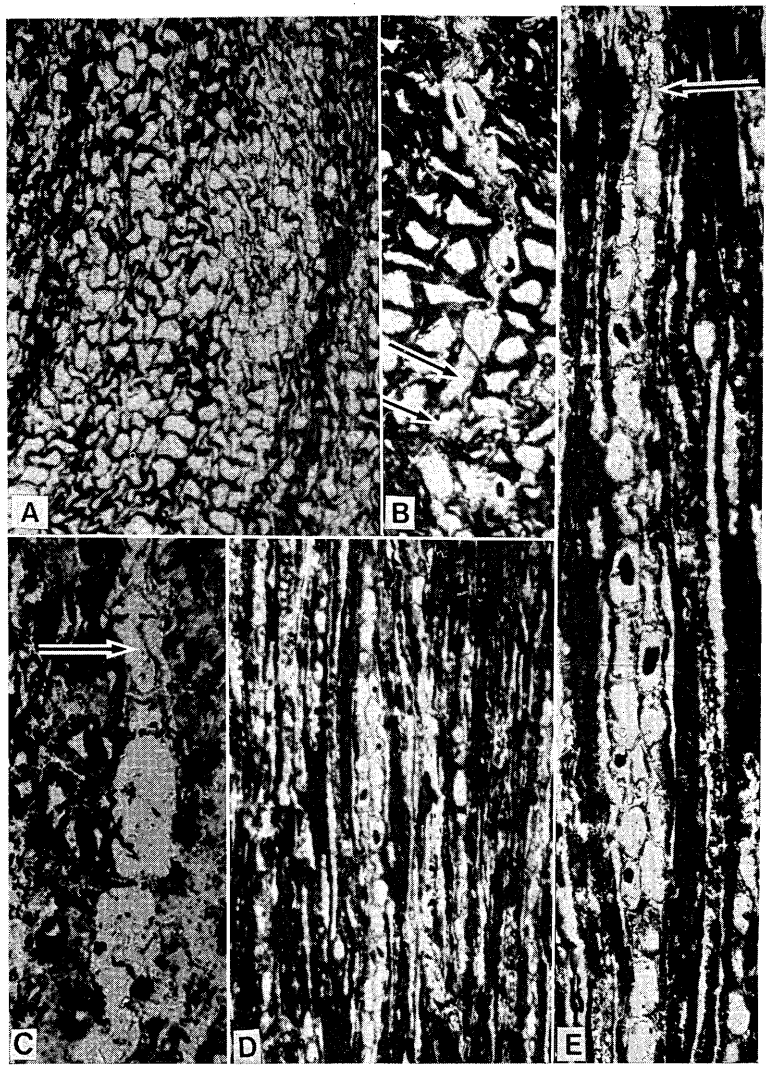
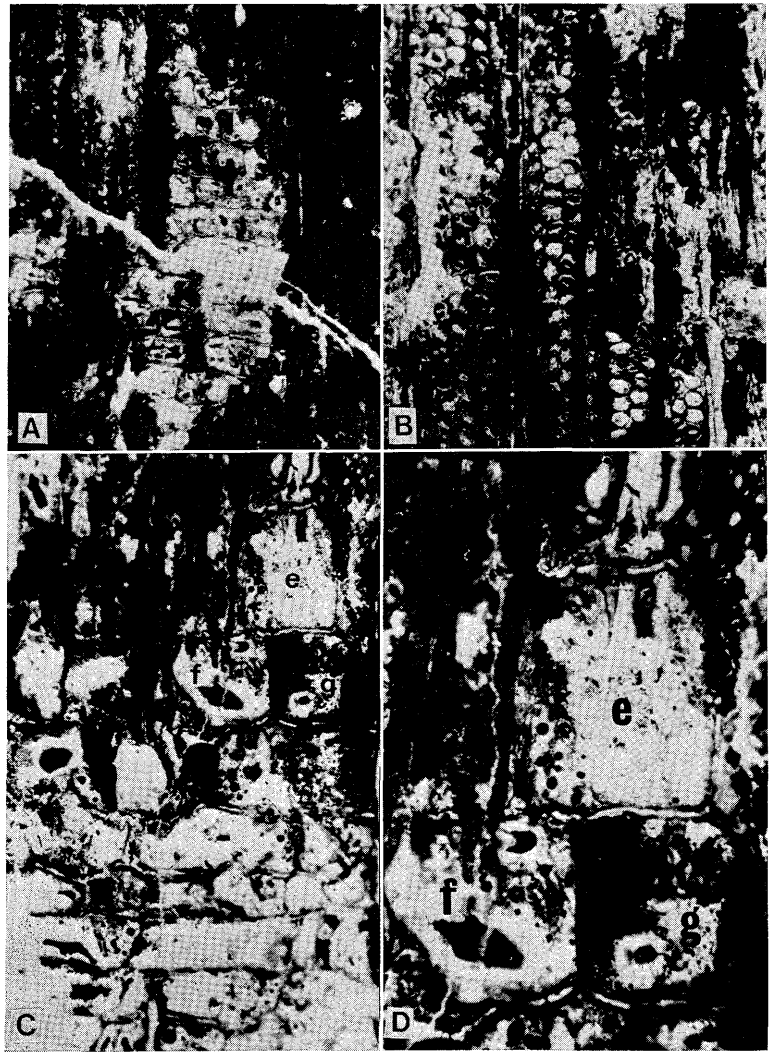
岩手県大船戸市立博物館より，同市内日頃市町鬼丸の下部石炭紀日頃市層から採集した硅化木の小片が送られて来た。産出した地層の時代から期待されたように，標本はナンヨウスギ型の材構造をもっていたが，また放射組織の細胞に恰も双子葉材の放射組織に見られるような方形細胞とほふく細胞のような2型性が見られた。このような放射組織は現生種または化石種とを問わず，今までに唯一の例外をのぞいて，知られていなかった。その例外はアメリカの上部デボン紀の前裸子類の樹幹 *Callixylon newberry* である。むろん本種は放射仮道管をもたないので *Callixylon* とは区別できる。このように際立った特徴をもつ本種に対し，古生代のナンヨウスギ型の構造をもつ材の新属として *Rikuzenoxylon* を設けた。下部石炭紀の材にデボン紀の前裸子類と共通の特徴が見られたことは系統学上興味がある。



M. NISHIDA & H. NISHIDA: *Rikuzenoxylon callixyloides*



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